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Unlocking Performance Advancements Using State-of-the-Art Digital Technologies

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Abstract

Over the last decade, the oil and gas industry has seen more changes than in most of its history. These changes have transformed the industry forever. Themes like factory drilling have given way to new project economics that can only be achieved after analytics carefully focus on KPI for each operator are combined with the ability to analyze large data sets around wells in the same basin, formations, etc. while correlating data that ranges from drilling and well placement to production estimates. These analytical perspectives of historical data combined with the availability of more real-time sensor data from the field than ever before and the increased availability of public data sources have paved the way for the digital transformation in the oilfield.

Moreover, digital implementation has gained momentum with a new generation in the industry. A new generation, raised with smart phones in their hands, exemplifies a data-driven approach as they fully expect to digitize most of what's around them for consumption by various models, think in visual models for information processing, and will to be a key factor driving the push for digital technologies.

Digital capabilities are quickly becoming both a requirement for corporate core competency for every organization, but also a disruptor – as many of the small start-up tech companies have forced old established companies to adopt economical, new technologies to remain competitive.

That said, the authors would like to show how the rise of this digital expertise has led to the creation of novel tools that are designed to increase the efficiency and productivity of people and assets as well as increase the chances of collaboration between operators and service companies. These digital tools, focusing on fluid properties, products, and system performance, have quickly added value by analyzing large data sets and presented them in a simple visual format all while focusing on practical, identified areas that can have an impact on the operators' overall performance.

Overview

Given the recent pressures placed on oil and gas operators and service companies by the extended economic downturns and a heightened focus on energy transition, industry stakeholders require that oilfield fluid systems be as green, efficient, and economical as possible. With the aid of new digital technologies this is not only possible, but can also be easily verified, sometimes in real time. The readily available data can be used to make quick, accurate decisions to change, modify, or continue current practices based on output from these new decision support systems.

As the industry faces new challenges to exceed current technical limits, minimize overages, and eliminate flat time, the ability to access to large caches of data and map relevant trends can be the difference between success and failure. In the past, operators relied heavily on the status quo when it comes to fluid selection. As fluids selection is a critical decision to make for any successful drilling campaign**,** operators can no longer depend on historical data with missing or inaccurate data. Software using digital technologies can map precise current, up-to-date trends, and provide operators and service companies with confidence in knowing they are using the best fluid system or product for the region or formation at current market conditions. Search parameters that narrow by region, system, date, and TVD allow the user to identify best practices more accurately and in real time. This coupled with a mapping feature provide visual confirmation the data being surveyed is accurate, pertinent, and functional for its intended purpose (Figure 1).

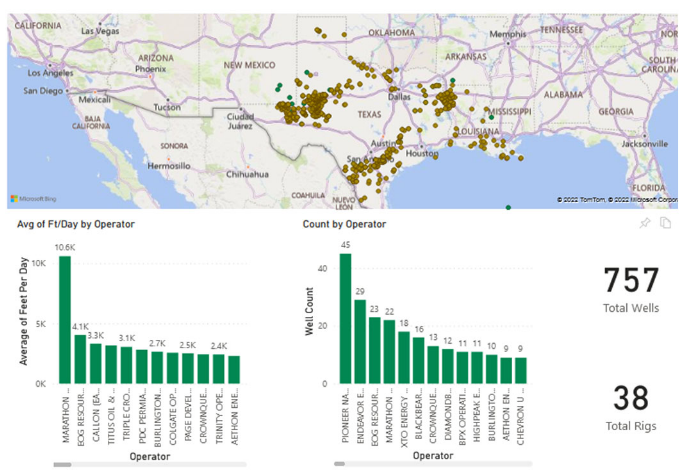

Figure 1: Digital dashboard focused on specific geographical area.

KPI tracking is also a well-known benefit of data analytics. KPI's are used to determine the performance of a procedure or select products. Two KPI's that are often used to determine efficiency are cost per foot and feet per day. Both indicators are affected by procedures and products. Many times, the cost/ft may be higher with the use of specialty products or new technology, but the trends show an increase in ft/Day. In many cases, the increase in ft/Day is enough to save significant rig time and thereby offset the added cost of the higher-end products and justifying the use of those products and/or fluid systems for specific regions and formations. Figure 2 illustrates the ability to graphically compare fluid types to drilling days.

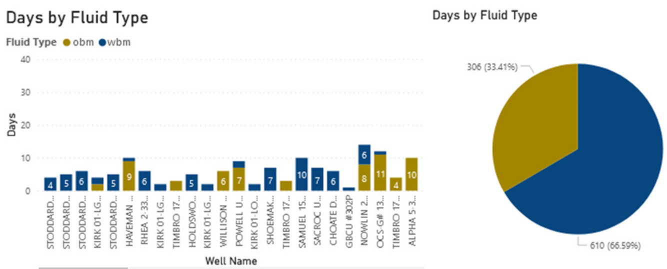

Figure 2: Graphic comparison of fluid type vs performance.

These digital solutions can be precisely customized to specific needs and the output shared with other team members or the client in real time.

In drilling fluids, any fluid lost translates to added expense for the additional volume required to maintain fluid parameters. By accurately tracking fluid losses, it is possible to verify the best products for the application. Figure 3 top graphic shows a traditional graph of the coating losses compared against measured depth. Again, the increased cost per unit of a superior product is offset by the savings in reduced amount of coating losses (Figure 3, bottom graphic). Figure 4 shows this information in a very different way, one that gets to the core of the cost savings in a much clearer fashion.

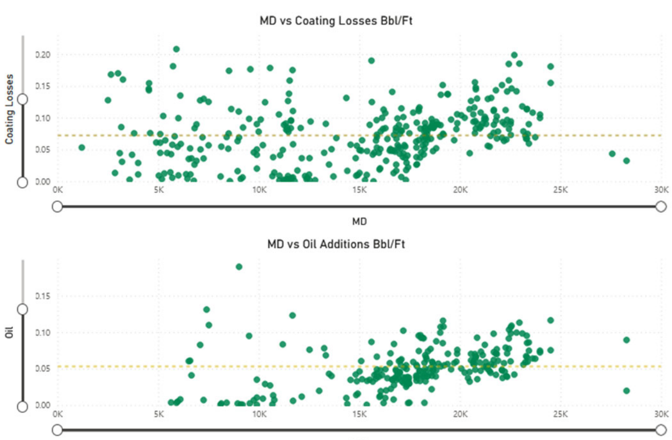

Figure 3: Coating losses by measured depth as compared to fluid lost shows the value of the KPI in reducing over all coating product losses.

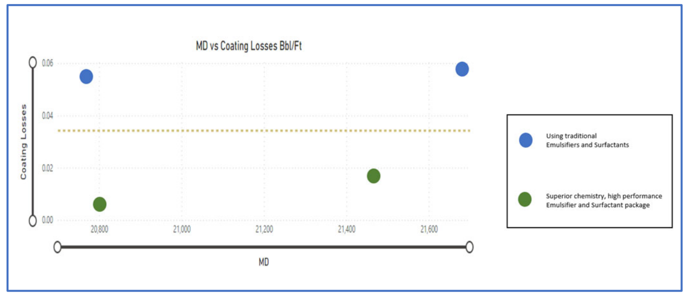

Figure 4: Digital technology graphic shows superior chemistry is more cost-effective in lowering coating losses.

Insufficiencies in a drilling program can also be identified by focusing on product consumption and dilution rates. Barite usage can be influenced by several things including lost fluid, additions made for well-control situations, and solids-control efficiency. Centrifuge settings greatly impact the amount of barite retained in a weighted fluid system as well as dilution rates associated with low-gravity solids removal (Figure 5). With the assistance of real-time monitoring and the ability to adjust the parameters of the centrifuge, and the use of a live data stream for real time monitoring and analysis, the overall barite and diesel consumption was reduced by an average of 30 tons of barite and 3897 gallons of diesel per well.

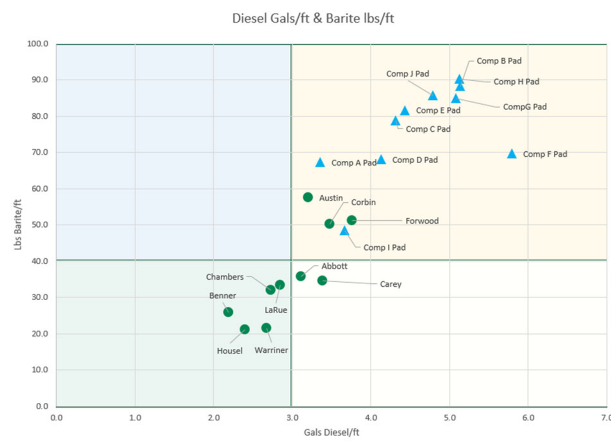

Figure 5: Real-time analysis led to significant reduction in barite and diesel consumption.

The use of software applications or "apps" has also become more common in recent drilling program planning and execution. Specialized apps can assist with various issues from well control to shaker screen selection. The benefits of digital evaluations become available to operators as well service companies as the real-time analysis and digital graphics are easily shared to all authorized uses. By using this data and the graphical solutions offered, it is easier to identify best practices and more accurately design drilling programs and fluids systems. Even with extensive planning, there may be unforeseen formation and operational challenges that must be overcome with the least possible interruption of drilling operations. Having an easy to use and accurate set of digital solutions at the ready, can save countless hours of rig time or non-productive time and provide added knowledge needed to make the drilling program successful.

Data Analytics

In a data-enabled organization the ability to perform detailed and current analysis helps transition the work force into a more efficient and leaner workforce providing both customer and service teams access to an efficient, accurate, consistent, centralized database of projects history. As data is captured from the real-time reporting, the digital solution technology collects and stores data in a large repository or a "data lake" which provides the foundational data for analysis by the analytical tools. The data lake is populated with public, historical, and current digital solutions simulation and real-time evaluations.

The "digital twin" concept in analytics means recording all data attributes of the offset wells, engineering simulations and real-time surface and/or downhole data in one record to enrich the user experience, thus helping the client to reduce time and increase efficiency in a visual understanding of the all the data.

Data analytics with innovative solutions is a window into the digital age where the drilling fluids sector was lagging compared to other drilling services and provides operational insights and modes to improve productivity and help close the knowledge gap in what is known as the "big crew-change". Figure 6 shows a workflow of data analysis with various types being on demand, post-mortem or near real-time depending on the fluid properties.

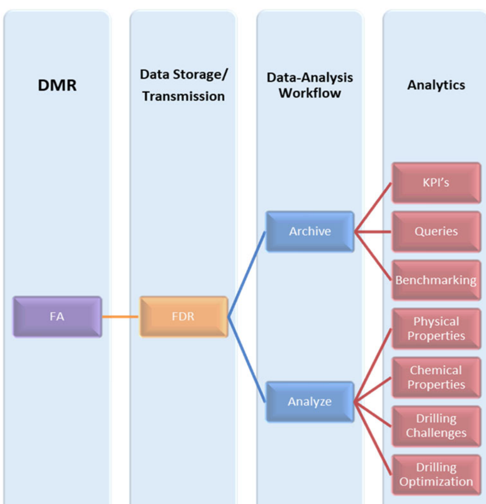

Figure 6: Twin analytics flow.

Data Storage and Profiling

Data profiling is the process of examining, studying, and reviewing data collected through the twin digital technology. The analysis looks at the statistics surrounding the quality of the dataset. Data quality refers to the accuracy, consistency, validity, and completeness of data. Data profiling, discovery, and data quality analysis are completed to create the data warehouse. Historical data, traditionally ridden with inconsistencies, is verified, analyzed, until finally "clean" data is imported to the data warehouse. The now clean data can be processed further with analytical tools to discover quality relationships creating a master database of reliable results on topics, such as pore size or mud density, and readily available for further mining or the data utilized as required for quick solutions.

The master database can now be profiled to provide the output analysis along with validations to ensure all data falls within any acceptable range as defined by the user. Profiling further reviews this data base to find where physical laws are violated, such as:

- TVD > MD
- Mud Density < 6 OR 25 < Mud Density
- Rheology = 0
- Negative consumption of products

Various tools and algorithms have been introduced to tackle the challenge of cleaning the data further. These tools include the use of SQL queries to profile data and handle the complexities of big data. This stage is where the need for automated self-service tools begins. The digital technologies described in the paper are necessary to move from using high quality data into the arena of advanced data architecture.

Data Architecture and Workflow.

The data lake was created from various data-streams which have now populated the data warehouse with verified and standardized clean data. The warehouse now becomes a hub for the other digital solutions to provide the Client and Partners the full digital picture for increased performance with less down time, greater efficacy, and heightened performance thus reaching the goal of value added by the digital technology. The workflow from collecting data, cleaning data, to using the data is seen in Figure 7.

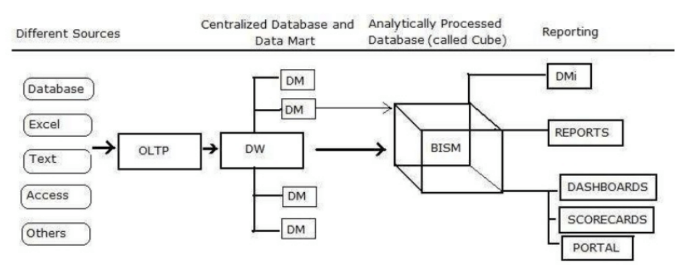

Figure 7: Data Architecture Workflow

Modern Fluid Reporting

Advances in data storage and transmission as well as user interface and graphic displays provide an opportunity to move this display from raw numbers to much easier to interpret graphics shown in Figure 8.

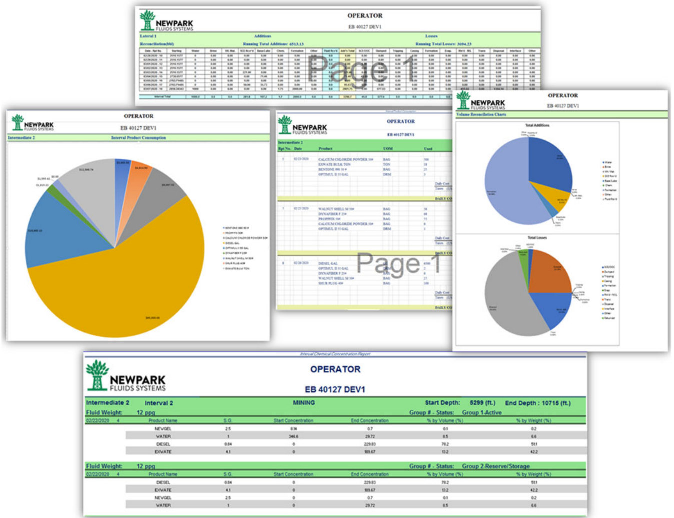

Figure 8: Fluids recap reports

A few differentiations applied are:

- Master data preservation to local and server-based data bases
- Client-focused benchmarking
- Customizable units, currencies, fluid properties labels, and other options are available
- Accurate volume accounting
- Customizable WITSML export for both 1.4.1.1 and 1.3.1.1

Engineering Simulations Built on Digital Twin Concepts

Hydraulics simulations which are needed for both well planning and monitoring field applications include a unique approach to combine discrete laboratory data for rheological parameters into continuous smooth surface spline interpolation scheme. This application of the twin suites can evaluate hydraulics in HPHT wells and provide multiple analyses on parameters such as surge and swab, hole-cleaning, and optimal use of LCM blends based on physics-based models that can be calibrated with the field surface data to better predict downhole drilling fluids behavior. Figure 9 shows some of the rheology and hole cleaning modeling work. Note the "risk zone" identified in the wellbore schematic on the far right.

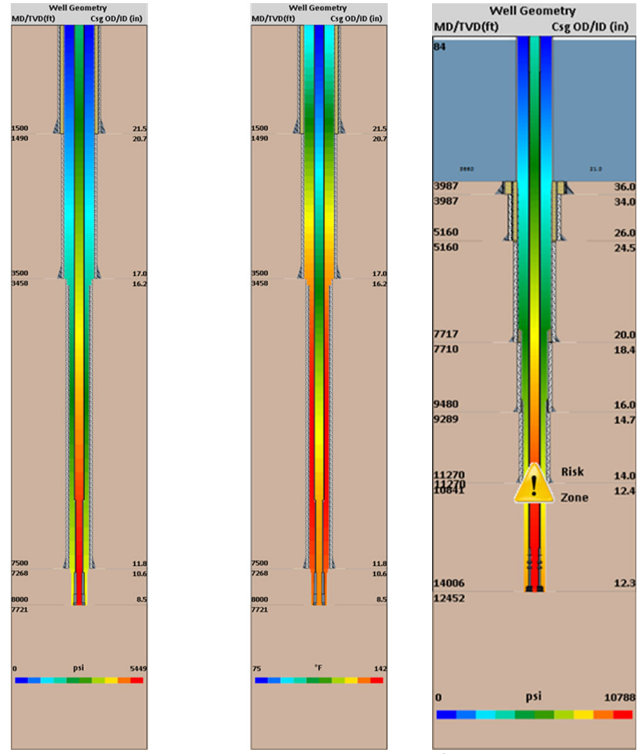

Figure 9: Hole cleaning model graphics. Colors and symbols indicate down hole data and critical risk zones.

Artificial Intelligence & Solids Removal Systems

In the solids removal system (SRS) described herein, the self-contained, skid-mounted, solids-control equipment is fitted with sensors that supply data in a live feed to create a digital twin. The live stream from the solids-control equipment provides real-time data from the centrifuge and dewatering unit which is analyzed per the background data from the data lake to provide a real-time dashboard view of the efficiency of the solids-control system and provide control both locally and remotely. Figure 10 shows the smart centrifuge dashboard.

Figure 10 – Smart centrifuge dashboard.

The SRS dewatering and centrifuge package is currently in service providing another tool to be utilized in the successful planning which incorporates captured historical data and real-time monitoring to provide better fluid management and ability to reach KPIs.

Figure 11 shows the diagram of the mapped sensors and values in the SRS system. The control of the SRS is controlled via a touch screen application. The parameters of each unit a fully adjustable on-site and remotely if required.

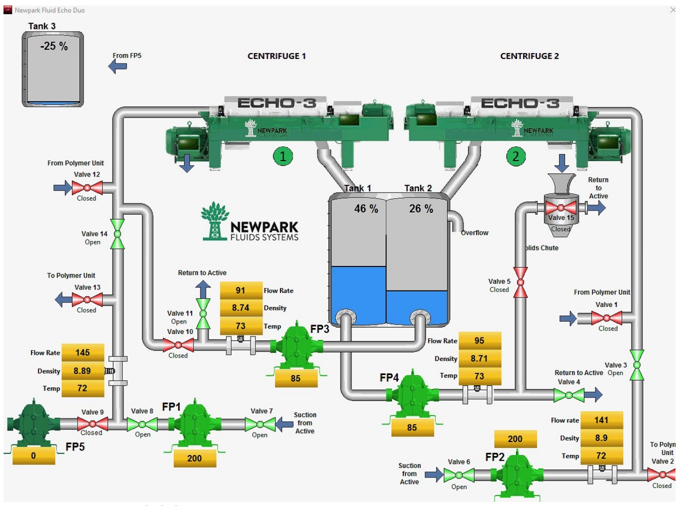

Figure 11: SCS schematic with outputs and color coded data monitoring checkpoints.

These real-time resources found in the dashboard combined with the historical stream gives the service engineering teams smart data to monitor the feed. This real-time capability has already proven the SRS value in a recent pack-off event. Figure 13 captures the event. Examination of the graph reveals an increasing fluid density in the barite recovery centrifuge (BR).

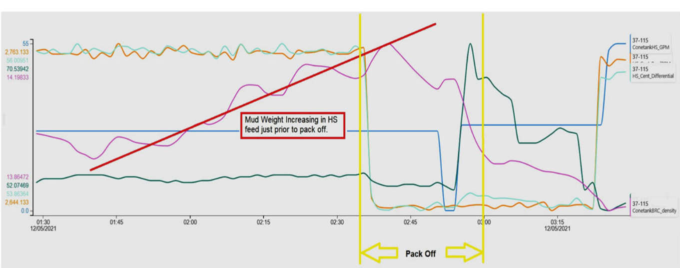

Figure 13: Real-time digital twin SRS data stream.

When the fluid density increased enough, the BR was overloaded as indicated by bowl RPM, torque and vibration. This in turn caused the safety mechanism within the system to trip and the centrifuges shut down. This application of data-driven technology proves the concepts laid out here are saving many hours of NPT, reducing downtime of the SRS package, and preventing the downstream effects of solids that would have been retained.

Conclusions

Unlocking performance advancements using state-of-the-art digital technologies is rapidly becoming the established practice, not just in data-centric organizations but also in independent exploration and production companies. Being able to access and adopt multiple data tools will require an efficient and cost effective approach to implement. The value-added results from deploying these digital tools will fuel a fundamental shift in processing of data and will force the industry members, large and small, to embrace it as it is the path forward.

The vital role of drilling fluids in successful drilling campaigns mandates that the fluids service companies must take the lead in providing these essential digital solutions. Through the experiences of the authors and partners we can deduce:

- Performance of fluids is already tied directly into digital solutions in current technology and even more so in the future with the creation of more sophisticated processes.
- The exiting data analytics workflows presented in this paper are a small sample of smart data analytics that can and will provide excellent insight and sharpen the expertise applied to real-time fluids management.
- Historical and public data sources will require a compressive data profiling and cleaning to populate the data lake required by the next generation analytics.
- New visualization tools are continually being created by data experts that may not have the full understanding of the data. This will require the blending of drilling fluids subject matter experts, visualization experts, and data analysis experts to leverage the full potential of the digital twins combining the historical and real-time simulations.
- These forward thinking and innovated process are providing a new and exciting future for the drilling fluids services to be leaders in digital technologies that will radically improve fluids management.

Nomenclature

HPHT = High Pressure High Temperature
KPI = Key Performance Indicator
LCM = Lost Circulation Material
NPT = Non-production Time
SRS = Solids Removal System

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